2010

MAP-MAKING AND THEORY-BUILDING: PRINCIPLES FOR ACHIEVING PRESENTATION AND CONTENT EFFECTIVENESS

Paidi O'Raghallaigh
University College Cork, paidioreilly@gmail.com

David Sammon
University College Cork

Ciaran Murphy
University College Cork

MAP-MAKING AND THEORY-BUILDING: PRINCIPLES FOR ACHIEVING PRESENTATION AND CONTENT EFFECTIVENESS

Completed Research Paper

Paidi O'Raghallaigh[1]
Business Information Systems
University College Cork
Cork

David Sammon
Business Information Systems
University College Cork
Cork

Ciaran Murphy
Business Information Systems
University College Cork
Cork

Abstract

As academic scholars in an applied field our central mission is to develop theory that both contributes knowledge to the academic discipline and applies that knowledge to practice. However, our efforts in this regard are impacted by communication deficits, which limit the effectiveness of our theories. The effectiveness of theory is attributable to the quality of both its presentation and its content. We put forward a model and principles to assist in building effective theory. The conceptual basis for this paper is the ancient craft and science of map-making. Perhaps controversially, we posit that theory-building efforts should focus primarily on 'effective theory' rather than 'good theory'. We conclude by proposing that in future our theories should be viewed as cognitive devices and that we need to understand which of their features contribute to making them successes or failures in different environments as well as why and how they work.

Keywords: Theory, theory-building, good theory, effective theory, research methods, cartography

[1] Corresponding author can be contacted at paidioreilly@gmail.com

Introduction

With theory-building seen as the basic aim of all science, it is difficult to overstate the importance of theory to the scientific endeavour (Colquitt et al. 2007). Scholars use theory to describe, explain and predict the phenomenon, as well as communicate its intricacies with others (Cook et al. 1979; Kuhn 1996). As academic scholars in an applied field our central mission is to develop theory that both contributes knowledge to the *academic discipline* and applies that knowledge to *practice* (Simon 1967; Van de Ven et al. 1989). But the heterogeneity of those consuming this research can be problematic with a number of serious communication gaps ensuing. Hirschheim and Klein (2003) categorise these 'disconnects' in terms of those afflicting the external *practice* stakeholders and the internal *academic* stakeholders.

Taking Shapiro et al. (2007 p. 249) as our point of departure, we posit that these communication weaknesses can be attributed to either a *knowledge translation problem* whereby our research findings are not being converted into a form that can be readily consumed by our stakeholders or rather more fundamentally as a *knowledge production problem* whereby our research is not in the first instance being aligned with the needs of our stakeholders. Both afflictions are endemic to our research efforts (*ibid*). The symptoms of the former are a *presentation issue* whereby our theories can no longer be understood by our stakeholders and the latter a *content issue* whereby we are not producing theories relevant to our stakeholders (Klimoski 1991).

Extant literature pays little head to these issues and indeed it is disconcerting to find that the virtues of so called *good theory* (c.f. Wacker 1998) are divorced from principles of effective presentation and content. We wonder how we can possibly prognose a theory to be 'good' when it can suffer from disconnects that severely blunt its effectiveness and make it incomprehensible and/or irrelevant to our stakeholders. The effectiveness of theory, which is detected from its cognitive impact on the reader, is attributable to the quality of both its *presentation* and its *content.* Instead of or in addition to *good theory*, we call on scholars to re-focus their efforts on building what we refer to as *effective theory*, which is incrementally and iteratively designed in order to be useful for its intended purpose and appropriate to its audience.

Unfortunately, the discourse on theory-building in Information Systems (IS) is akin to the proverbial rabbit that finds itself caught in the headlights of an oncoming car. We are told that urgency is required as our academic field is in a state of decline owing to weakness in our theory-building efforts. Yet inertia persists and there continues to be surprisingly little discussion in our field of what constitutes theory and even less of how we should go about building it. Instead of waiting flatfooted for the collision, this paper seeks to address this anomaly.

The remainder of this paper is structured as follows. We begin by reviewing the state of theory-building in IS. The next section provides an overview of the association between maps and theories. We follow this with an outline of the translation and production problems facing scholars when building theory. Then we explore map-making and map-reading to seek out insights useful for informing effective theory-building. In the penultimate section we use these insights to derive a model and principles to guide the building of *effective theory*. The paper concludes with a discussion of what these principles mean to research and in particular to IS research.

The exploration of theory-building in this paper is inclusive. First, the discussion is not specific to the adoption of a particular epistemological position. Second, consistent with Gregor (2006), we take a broad view of theory and we do not restrict the discussion to a particular type of theory. In these ways the paper is intended to appeal to as wide a range of scholars as possible.

State of Theory-Building in IS

Issues of identity and legitimacy are important in all academic fields, including the IS field. The strengthening of identity and legitimacy among stakeholders is a mark of a field's growing maturity (King et al. 2006). But the nascent IS field demonstrates continued insecurity regarding its identity and legitimacy and there is significant disagreement on how concerned we ought to be and what, if anything, we should do about these concerns. Some authorities (e.g. Benbasat et al. 1999; Hirschheim et al. 2003) suggest that the IS field is in danger of disappearing if the concerns are not addressed aggressively. Others (e.g. Galliers 2003) are less concerned suggesting that these concerns are not really worthy of undue concern. When it comes to suggesting a solution there are also contrasting views. At one end of the scale are those who believe that identity and legitimacy go hand in hand with a sustained intellectual focus. The identity of successful academic fields among their peers is built around strong theories at

their epistemic cores (Bakshi et al. 2007; Benbasat et al. 2003; King et al. 2006; Weber 2003; Weber 2006). For example, Weber (2003 p. vi) states that "*the identity of a discipline is established through the contributions it makes to theory. The core phenomena of the discipline are circumscribed via the theories 'owned' by the discipline that account for these phenomena*". Toward the other end are those who argue that a fluid identity embracing "*multiplicity of intellectual perspectives … is the only realistic way of hitting all the important research targets and reaching legitimacy*" (King et al. 2006 p. 350). But there is disagreement about the relationship between identity and legitimacy. Benbasat and Zmud (2003 p. 185) argue that *"[i]f influential stakeholders are unable to comprehend the nature, importance, and distinctiveness of … the IS discipline, these stakeholders are unlikely to acknowledge its legitimacy within the organizational field"*. While many agree, others such as Weber (2003; 2006) contend that a *clear disciplinary identity* is neither a necessary nor sufficient condition for academic legitimacy. There is no evidence to suggest that the creation of theory makes legitimate a field that lacks legitimacy (Lyytinen et al. 2004).

While arguments continue into the role theory-building plays in the attainment of identity and legitimacy, it is almost impossible to find anyone in the debate who argues that theory is unimportant, or that strengthening the field's principal theories is undesirable. Instead there appears to be "*broad agreement on the general value of theory, per se"* as it can enhance the field's cognitive or pragmatic legitimacy (King et al. 2006 p. 349). In other words while it may be impossible to conclude that theory is equated with legitimacy it is at least contributory to the legitimacy of the field among its internal and external stakeholders. But this legitimacy depends on the *social salience* of the topics studied as well as the presence of strong results and the ability to maintain disciplinary plasticity (Lyytinen et al. 2004). Ultimately, legitimacy of an academic field comes from receptive stakeholders agreeing that the field provides them with relevant research of real value (King et al. 2006).

Maps and Theories

Maps[2] are one of the oldest forms of human communication and have long been used by people to orientate themselves in both their natural and spiritual worlds (Okada et al. 2008). A map *is not* the territory it depicts (Korzybski 1948 p. 58), but is instead a *representational model* of a geographic reality. In other words map-makers depict "*one kind of space in another kind of space*" (Berendt et al. 1998 p. 3). But maps are also effective *cognitive devices*, which allow the map-reader "*to perform operations that cannot be performed directly in the represented space*" (*ibid* p. 3). According to MacEachren (1992a) evidence shows that cognitive representations generated from maps are, firstly, image-like and, secondly, can be mentally manipulated and scanned for information. Learning an area from a map has been shown to sometimes result in mental images that allow for more accurate estimations than learning the area by being in it (MacEachren 1992b). For example, Lloyd (1989) demonstrates how ten minutes of studying a map results in more accurate distance and direction estimates than ten years of living in the area depicted by the map. However, mental images derived from map-reading can also suffer from limitations such as orientation rigidity whereby the map-reader struggles to re-orient the image in order to judge directions to a destination (MacEachren 1992b). Nevertheless, maps are generally successful in communicating geographic knowledge and are also in increasing understanding and solving geographic problems even for novice map-readers (Barkowsky et al. 1997; Krygier et al. 2005).

A close association between maps and theory has been noted with some scholars, such as Geller (1991 p. 42), suggesting that "*[m]aps are a metaphor for science*". For example, Griffin (1991) uses the metaphor of the map to explore the purpose and meaning of theory. "*Theories are maps of reality. The truth they depict may be objective facts 'out there' or subjective meanings inside our heads. Either way, we need to have theory to guide us through unfamiliar territory*" (Griffin 1991 p. 4). Nastasia & Rakow (2009) suggest that the idea of theory as map-making is an ancient one. However, they also caution that conceptualising theory as map-reading can be problematic as it creates "*a view of the object of study or problem as given and taken-for-granted … as exterior to the theorist, overcoming individual theorists, or as more venerable and more important than studying subjectivities*" (p. 3).

In general, "*theory answers a human need to make sense of the world and to accumulate a body of knowledge that will aid in understanding, explaining, and predicting the things we see around us, as well as providing a basis for action in the real world*" (Gregor 2002a p. 15). There appears to be consensus among theory-building authorities (e.g. Campbell 1990; Dubin 1978; Wacker 1998; Whetten 1989) that theory has four basic components: *constructs*,

[2] There are many meanings of the word 'map' Here we're concerned with traditional paper-based maps that depict a geographical reality.

relationships, *domain limitations*, and *predictions*. In addition, a *good theory* has the virtues of *uniqueness*, *parsimony*, *conservatism*, *generalisability*, *fecundity*, *internal consistency*, *empirical riskiness*, and *abstraction* (Wacker 1998). Juxtaposing the characteristics of maps and the components of theory – see Table 1 - we conclude that there are indeed striking parallels between maps and theories, which justify adoption of the former as a metaphor for the latter. We feel that maps and map-making may be useful in shining new light on our theories and theory-building efforts. But first we will review the academic discourse to ascertain what it has to say about useful theory, how we should build it, and issues to be avoided.

Table 1. A Review of the Characteristics of Maps against the Components of Theory

Component of Theory	Brief Description of Purpose	Characteristic of a Map[3]
Construct	Defines the constructs included in and excluded from the theory.	A map is a visual representation of a geographical space consisting of cartographic *entities,* indicated by pre-defined symbols, placed in a bounded space. A meta-knowledge defines and guides interpretation of the cartographic entities.
Relationship	Defines and explains the relationships among the constructs.	The map is a visual representation of the spatial relationships between the positions of actual objects in geographic space. Again a meta-knowledge defines and guides interpretation of the cartographic relationships.
Domain Limitations	Specifies the conditions under which the theory is expected to hold.	Maps are bounded to a particular geographic space and to a particular point in time. The map-maker's personal experience and intellectual abilities, as well as cultural, political, and economic dimensions, also bound the map.
Predictions	Gives specific predictions that can be tested to determine if the theory holds in certain contexts.	Maps are not simple representations but visual propositions that affirm for each cartographic entity that '*this is there*'. Indeed maps may post things that don't yet exist, things that have ceased existing, or that are outside the realm of existence.

Problems in Building Useful Theory

The primary criteria upon which any theory may be evaluated are its *falsifiability* and *utility* (e.g. Bacharach 1989; Doty et al. 1994; Hempel 1965; Popper 1959). On the one hand, a theory must be constructed so that empirical refutation is possible. On the other hand, a theory must be constructed so that it provides utility through useful explanation and prediction. A theory is useful if it both explains and predicts whereby an explanation establishes the substantive meaning of constructs, variables, and their linkages, while a prediction tests that substantive meaning by comparing it to empirical evidence (Bacharach 1989). The strength of the theory's explanation and prediction is derived from the *accuracy* of its relationships (Burton-Jones et al. 2004) as well as the *domain* or extent of those explanations and predictions (Campbell 1990; Lynham 2002; Van de Ven et al. 1989; Whetten 1989). Theory should be applicable to as broad a domain as possible (e.g. Metcalfe 2004; Popper 1959; Wacker 1998; Weick 1989; Weick 1999). The domain of a theory is determined by its *generalisability* and *abstraction*, which address questions of *Who*, *Where*, and *When* (Whetten 1989). A theory's generalisability can be defined as the extent to which a theory can be applied to existing populations (Wacker 2008a) whereby the wider the population to which the theory applies, the more general the theory is. For example, an explanation of why people appear overly abrupt when using email would be less general than an explanation of their behaviour across all forms of electronic or asynchronous communications (Metcalfe 2004). On the other hand, abstraction can be defined as the extent to which a theory's application is void of time and space requirements (Wacker 2008a) whereby the more independent the theory is of time and space, the more abstract it is. Thus a narrow domain decreases the generalisability and the abstractness of the theory, while a broader domain increases it's generalisability and abstractness (Bacharach 1989; Wacker 2008b). Generalisability and abstraction mostly work together so that higher "*generalizability requires a higher level of abstraction*" (Bacharach 1989 p. 500). In this paper we use the term *generality* to refer to the combination of generalisability and abstraction. But high generality is not achieved without a cost in terms of building *effective theory*. Klimoski (1991) reminds the scholar that we need to concern ourselves not just with the "*content (e.g., the nature, derivation, form and structure) of [our] arguments [but also] …the way that they are presented*". Hence we now direct our attention in turn to issues of presentation and content effectiveness.

[3] After: Barkowsky & Freksa, 1997; Berendt et al., 1998; Krygier & Wood, 2005

Translation Problem and Presentation Effectiveness

The question that concerns us in this section is how theory-builders should address the *translation problem* to ensure the *presentation effectiveness* of theories and hence maximise their usefulness. We define presentation effectiveness as the ability of our theories to *effectively* convey the maximum number of ideas to our intended audience with the minimum amount of ink. We remind the reader that the intended audience for research can be made up of both internal and external stakeholders.

The ability of language and especially scientific language to transfer ideas is eroding due to its increasing complexity and specialisation (Daft 1980; Rynes et al. 2001). In addition, language is restricted in the number of dimensions through which it conveys information. Language when aural is sequential owing to the sound waves arriving in sequence at the ear of the listener. Language when visual is also sequential as the eyes of the reader process words in the order they appear on the page. These sequential representations are sometimes referred to as one-dimensional whereas visual representations are two- or three-dimensional (Crapo et al. 2000). Visual representations can be processed by the visual portions of the human brain (Larkin et al. 1987), which can discern within milliseconds visual features such as motion, colour, intensity, size, intersection, closure, orientation, lighting direction, and distance (Crapo et al. 2000). The result is that we usually interpret stimuli reaching our eyes in at least a three-dimensional manner (Crapo et al. 2000).

But "*[o]ur ability to process and think about information relating to the three dimensional world is not limited to what we see*" (Crapo et al. 2000 p. 220). For example if we are asked to compare two objects that are out of sight then our minds are able to create mental images of both from which we can draw conclusions. But as the complexity of the image increases, we struggle to effectively construct, maintain, and manipulate it in memory (Finke 1990). Hence*"[t]he capacity of the human mind for formulating and solving complex problems is very small compared with the size of the problems whose solution is required"* (Simon 1957 p. 198). For this reason use of mental images to understand and solve complex problems becomes "*increasingly inferior to our ability to use an external visualization to solve the same problem*" (Crapo et al. 2000 p. 220). Pinker (1999) suggests that the ability of the human mind in such circumstances can be improved with the assistance of appropriate visualizations[4]. A model is a visualization that offers an "*external and explicit representation of part of reality as seen by the people who wish to use that model to understand, to change, to manage, and to control that part of reality in some way or other*" (Pidd 1999 p. 120).

The advantages offered by models are multi-fold. First, models can function as external extensions of '*working memory*' by anchoring at least some aspects of our mental images (Crapo et al. 2000). Second, models through their limited expressiveness reduce the degrees of freedom of expression, thereby making interpretation easier (Crapo et al. 2000). For example, while language allows us state that one object is positioned next to another without having to specify which is on the left and which is on the right, models do not afford us such ambiguity thereby reducing obfuscation (Pinker 1999). Third, a model can be used to externalise knowledge and assist in communicating with others (Crapo et al. 2000) and ultimately in increasing group understanding and resolving group differences (Massey et al. 1996). "*Ideally, the result of this interaction is a group cognitive structure that is better, in some sense, than the starting model of any one individual*" (Crapo et al. 2000 p. 222). Fourth, a model is a representation of some reality (Hughes 1997), which is amenable to examination and manipulation thereby supporting *surrogative reasoning* whereby someone can use the model to learn something about a reality or *surrogative inferences* whereby someone can use the object to reason about the reality (Swoyer 1991).

Despite presentation being an integral part of many definitions of theory, it remains largely ignored in the academic discourse on theory-building. There is a serious dearth of academic discourse on how we should present theory to the reader and how we should overcome the limitations of the sequential representations of spoken and written words in depicting a "*world … [that] does not function in linear order*" (Mintzberg 2005 p. 13). Given that the "*visual is often more effective than the verbal*" (p. 212), Krygier & Wood (2009) wonder how we can deem the visual to be "*so inappropriate as formal academic discourse*". Conversely in map-making '*the visual is the message'* (Krygier 2008). Through its long history of designing and producing effective visual representations

[4] This paper distinguishes the words *visual, visualization,* and *model,* which refer to representations external of the human mind, from the words *image* and *imagery,* which refer to mental images.

(Berendt et al. 1998), map-making has much to offer the scientific community (Geller 1991; MacEachren et al. 1997) in wrestling with presentation issues. We return to this point later in the paper.

Production Problem and Content Effectiveness

The question that concerns us in this section is how we should address the *production problem* to ensure the *content effectiveness* of our theories. We define content effectiveness as the ability of our theories to *effectively* produce information appropriate to our intended audience and their needs. For example "*[t]ranslating findings in ways that are understandable to broader audiences will be more appreciated when these findings relate to phenomena that matter to the message receivers*" (Shapiro et al. 2007 p. 249). Therefore, useful theory-building is not just a matter of overcoming the translation problem through achieving presentation effectiveness but also a question of achieving content effectiveness or as Klimoski (1991 p. 264) suggests ensuring the "*quality of the ideas themselves*". But the effectiveness of the ideas is moderated by questions of generality, simplicity, and accuracy.

Unfortunately there is disagreement among theory-building authorities as to the optimum level of generality, simplicity, and accuracy in theories. Mintzberg (2005 p. 19) wonders "*[w]hat … is the problem with a sample of one … Piaget studied his own children; a physicist once split a single atom. Who cares, if the results are insightful*". But this view is obviously a problem for most other theory-building authorities with Popper (1959) among others (e.g. Metcalfe 2004; Wacker 1998; Weick 1989; Weick 1999) suggesting that theory should be applicable to as broad a domain as possible. They advocate that scholars increase the domain of application of their theories with the result that as time progresses fields of research climb towards increasing generality (Wacker 1998). But high generality results in theories that are largely *context-free* "*despite the fact that the context out of which they have been developed is often very rich*" (Bartunek 2007 p. 1327). Mahoney & Sanchez (2004 p. 35) identifies the *principle of contextualism*, which "*recognizes that there is a context-dependent gap between concepts of universal theory and concepts useful in a specific context*". This makes the former highly erratic in accuracy across different contexts (Markus et al. 1988). A call for the contextualism of theories is therefore gaining voice (e.g. Barnes et al. 1994; Mahoney et al. 2004; Merton 1967; Schneberger et al. 2009; Weick 1974). While contextualism increases the accuracy of a theory in a particular context, it does so at the expense of simplicity. But Wacker (1998 p. 366) questions the usefulness of detailed theory owing to its complexity and the fact that it "*only applies to a few instances"*. Likewise Colville et al. (1999) warn that practitioners may find complex theories uninteresting, which may mean that they are unlikely to use them. Contextualism could thus limit the usefulness of theories.

Advice from extant literature, therefore, takes the reader around in proverbial circles and offers no clear way forward. The literature does, however, allow us surmise, as do Thorngate (1976), Sutton et al. (1995), and Weick et al. (2005), that generality, simplicity, and accuracy cannot be achieved concurrently within a single theory. Increased generality demands simplicity, which is achieved at the expense of accuracy. On the other hand, reduced generality is associated with more complexity and more accuracy. Therefore "*no one theorist can have it all, "all" being an explanation that is general, accurate, and simple"* (Weick 2005). In practice theories lie in the space between "*empirical generalizations (rich in detail but strictly bounded in space and/or time) … [and] grand theoretical statements (abstract, lacking in observational detail, but relatively unbounded in space and/or time)*" (Bacharach 1989 p. 500). Bacharach (1989 p. 500) refers to the paradox whereby "*some of the most detailed theories and elaborate studies … are not generalizable enough to build a cumulative body of research on"* but, on the other hand, "*some of the most abstract and broad perspectives … while not necessarily rich in detail, have provided a critical basis for cumulative research"*. Theory-builders must be pragmatic and have no option but to make tradeoffs between generality, simplicity, and accuracy (Sutton et al. 1995). But extant literature provides little assistance to scholars faced with the challenge of building useful theory under a barrage of strong and oftentimes conflicting interdependencies between generality, simplicity, and accuracy. For centuries map-makers have successfully grappled with these issues and map-making can provide theory-builders with useful cues as to how to rise above the content conundrum. We return to this point later in the paper.

Map-Making and Map-Reading

The process of map-making consists of transforming the map-maker's conceptualisation of geographical reality into a map (Barkowsky et al. 1997). On the other hand, the process of map-reading consists of the map-reader inversely transforming the map into a mental image of the original geographical reality (Barkowsky et al. 1997). These relate to processes of encoding and decoding geographic information respectively. The process of decoding maps cannot

be easily achieved for many reasons. First, the map-making process involves a loss of geographic information because the "*real world can't be caught by a map*". Second, the process of map-making is not formal and may be largely unknown to the map-reader (Barkowsky et al. 1997). Instead it is largely a creative process through which the map-maker's personal experience and intellectual abilities 'colours' the map (Anson et al. 2002). Such biases remain unknown to the map-reader (Anson et al. 2002; Harley 1989). Third, the map-maker and map-reader must share a cartographic language that includes a common understanding of a library of cartographic symbols (Anson et al. 2002; Berendt et al. 1998). Fortunately over the centuries such a cartographic language has emerged making the knowledge and skills applicable to making and reading one map applicable to other maps (Berendt et al. 1998).

Prior to the 1960s map-making was explained simply as *map production* (Anson et al. 2002). But effective maps do not simply get produced, they must be carefully *designed*. Robinson (1952) called for an approach that refocused map-making away from map production towards both map design and map use. A critical factor in the success of maps as effective cognitive devices is their visual appearance, which in turn "*depends on explicit and implicit design decisions made by mapmakers*" as to their presentation and content (Montello 2002 p. 285). Over the past few decades, map-makers have devoted considerable attention to understanding how the visual design of maps acts as a cognitive device for the map-reader (MacEachren et al. 1997; Montello 2002). Visual excellence is the well-designed and purposeful presentation of interesting data, which ensures that complex ideas are communicated with clarity, precision, and efficiency (Krygier 2007).

It is not possible to depict geographical areas, which are large, complex, and full of natural and man-made features, at their actual size nor would it be possible to show their full detail. Maps are designed to serve certain specific purposes and therefore represent only a select set of the spatial features of geographic areas (Berendt et al. 1998). For these reasons maps are strategically reduced in *scale* and *generalized* in order to emphasize some aspects of the geographic area but to deemphasize or omit everything else (Krygier et al. 2005). The *scale* of the map is the mathematical relationship between the size of the map and the size of the geographic area it represents. As the map-maker reduces the scale fewer individual features can be displayed on the map. For example at a scale of 1:100 all the individual trees in an area might be depicted, but this would be impossible at a reduced scale of 1:100,000. The correct choice of scale depends on the purpose of the map. This generalization is necessary in order to cope with output space restrictions, ensure that the cartographic entities are visually recognizable at the given scale, and prioritise the cartographic entities according to the purpose of the map (Barkowsky et al. 1997; Li et al. 1993). Generalization can be achieved through five operations: (1) selective omission, (2) simplification, (3) combination, (4) exaggeration, and (5) displacement (Keates 1989). For example, when representing a wooded area the map-maker may decide to show no trees, show only a selection of the trees, show the trees as a single forest area, enlarge the trees or forest area, or move the trees or forest area. Each approach may be valid in different circumstances depending on the purpose of the map.

While scaling is largely an objective process, generalization is an ad hoc and subjective process, informed by the intuition and artistry of the map-maker as well as the purpose of the map (Li et al. 1993). But at all times, the map-maker must attempt to retain "*the greatest possible accuracy, with respect to the scale of the map*" (Imhof 1982 p. 86). Map accuracy refers to the amount (or lack) of distortion in the representation of features. But map accuracy is difficult to determine. Large-scale maps tend to show less area but in more detail through less generalization, while small-scale maps tend to show larger areas but in less detail through increased generalization. The smaller the scale is then the larger the degree of adjustment that is required and, therefore, the greater the misrepresentation that results (Li et al. 1993). However, this misrepresentation may be necessary in order for the map to ensure the legibility of objects of interest – all within the limited scale of the map. An example is the case of maps where roads and railways are displayed. Both of these features are often built close to each other, meaning that on many maps their symbols would overlap and be illegible. But generalisation allows for both to be displayed on a map by moving one relative to the other. The inaccuracies resulting from such generalisation are deemed to be acceptable provided they do not prevent the map from achieving its purpose. Maps therefore represent only a select set of features of the geographic area they depict, and are highly imprecise with respect to other features, even omitting them when they are not necessary (Berendt et al. 1998). Modification and omissions from such maps should not be misinterpreted. When addressing the issue of accuracy, the question may, therefore, not be whether the map is *accurate* but whether the map is *appropriate* for its intended purpose. For example, the schematic representations of urban underground rail networks focus on depicting the sequence of stations on the lines and their general direction but omit most of the topographic information including accurate distances between stations (Berendt et al. 1998). The map of the London Underground, for instance, is "*neither accurate nor to scale*" (Colville et al. 1999 p. 142) yet is deemed appropriate for its purpose, which is to assist the passengers in identifying the line and the number of stops to their destinations.

Indeed the map is often referred to as an exemplar of effective map design on account of its presentation and content.

Map effectiveness, as originally intended by Robinson (1952), is the ability of the map to capture and portray relevant information in a way that the map-reader can analyse and interpret (Kitchin et al. 2009). To ensure their effectiveness, maps should be evaluated to "*understand the effects of design decisions on the minds of map users*" (Montello 2002 p. 285). Krygier (2007) states that *"[t]here are different kinds of evaluation, from documentation of your design and production process, to formative evaluation (where you or others critique and revise your map as it is produced), and, finally, impact evaluation where formal methods are used to assess the effectiveness of the map among a subset of its intended audience"*. As "*maps function, for better or worse, via their visual appearance*" (Montello 2002 p. 286) then their appearance is designed and evaluated iteratively in order to ensure their positive impact on the map-reader. Map-making efforts are informed by both craft and science. Trial and error over centuries had resulted in a traditional *craft approach* towards the design of maps, but this approach has more recently been enhanced with a more scientific understanding, such as provided by cognitive science (Jenks 1987; Montello 2002). While "*cognitive research has taught us some things about making better maps, and undoubtedly will teach us more, it is never going to replace completely the wisdom and aesthetic sensibility of a good designer*", who relies on design principles that have been decades and even centuries in the making (Montello 2002 p. 298).

The craft and science of map-making are of use to us in this paper in our attempts to arrive at a set of principles for the building of *effective theory*. In the next section we present our contribution to the discussion of effective theory-building.

Contribution to Effective Theory-Building

We remind the reader that *effective theory* is incrementally and iteratively designed in order to be useful for its intended purpose and appropriate to its audience. We next build on insights from map-making[5] to derive a process (see Figure 1) and principles (see Table 2) for building *effective theory*. Effectiveness is *designed into* an emerging theory through searching through alternative *presentation* and *content* options and evaluating their (perceived) cognitive impact on the audience. The emerging theory is not effective if it is inappropriate in presentation or content and thereby fails (or would be likely to fail) in having the desired impact on the audience. In other words effective theory-building is a *design process* driven by a research problem and the search for an effective theory to address the research problem. The research problem emerges from the environment (Simon 1996) which in the case of IS research is composed of people, organizations, and existing or planned technologies (Silver et al. 1995).

[5] The process and principles are influenced by the discussion presented in the previous section as well as the 'Five Principles of Cartographic Design' from the British Cartographic Society's Design Group - accessed and viewed at http://makingmaps.net/2008/02/05/more-principles-of-map-design/

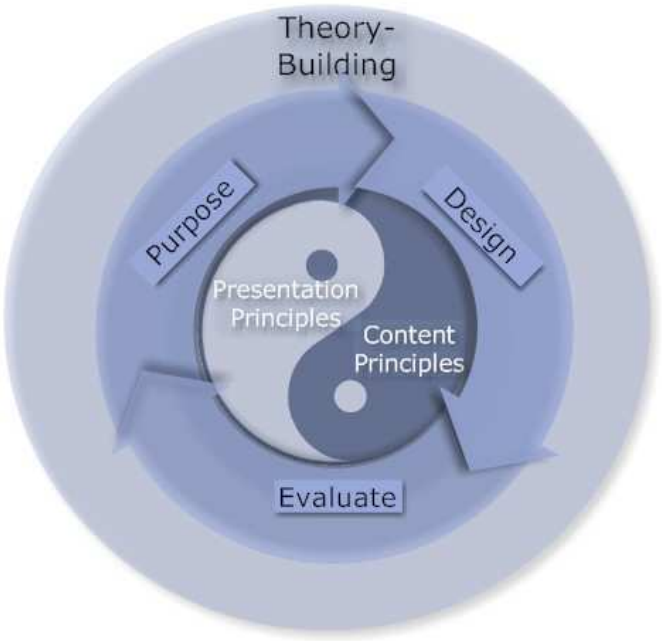

Figure 1 - Process of Effective Theory-Building

Characterising theory-building as a design process is noteworthy in a number of regards. Firstly it implies that theories are purposefully *created* rather than deductively *discovered* as much of the scientific literature would have us believe (Mintzberg 2005). We are not the first to claim that theories are created (c.f. Hempel 1965) but we are, to the best of our knowledge, the first in IS to make the *purposeful design of theory* the focal point of our work. Secondly, it implies that theory-building is inherently iterative and incremental consisting of "*the purposeful process or recurring cycle by which coherent descriptions, explanations, and representations of observed or experienced phenomena are generated, verified, and refined*" (Lynham 2000 p. 161). In other words the perspective of the scholar continuously shifts between the *design* of theory and the *evaluation* of the emerging theory. Thirdly, it implies the search is for an *effective* theory rather than a *true* theory (or in the words of Simon (1996) for a *satisficing* solution rather than an *optimum* solution). Fourthly, it implies that the resulting theory must be evaluated for *utility* to ensure it appropriately addresses the research question. The resulting theory should also be *novel* and so it must either address a heretofore unsolved problem or address a known problem in a more effective manner. Fifthly, representation has a profound impact on design work and the search for an effective representation is crucial to both finding an effective solution as well as communicating it (Hevner et al. 2004; Simon 1996). We therefore reiterate that the visual has a key role to play in theory-building.

We outline various additional principles in Table 2 to guide the design and evaluation of the emerging theory. We previously used these principles to create a typology of knowledge activities for innovation studies (c.f. O'Raghallaigh et al. 2010). Essentially all the principles can be boiled down to ensuring that all decisions in the design and evaluation of theory (such as the required level of generality, accuracy, and simplicity as well as its presentation) must be driven by the intended purpose and the ultimate audience (which jointly we refer to as ensuring that the theory is *purposeful*). We divide these into presentation- and content-aware principles, which are drawn directly from our previous discussions. We suggest that content and presentation effectiveness are two sides of the same coin - the proverbial coin that is theory effectiveness. One without the other is worthless and therefore we must ensure that our theories are designed to have both.

Table 2. Deriving 'Principles for Effective Theory-Building' from Map-Making				
Principle	Problem[6]	Lesson from Effective Map-Making	Example from Map-Making	Implication for Theory-Building
An effective map/theory is purposeful	P/C	Before making an effective map, the map-maker clearly identifies the purpose of the map and the audience for whom it is to be produced.	A street map would be of limited value to a map-reader who must navigate an underground rail system. While it may be of correct area and scale it serves a different purpose which limits its usefulness.	The function of theory-building is not to build general, accurate and or simple theory per se but to produce purposeful theory. Effective theory is purposeful to a given audience.
An effective map/theory is designed	P/C	Effective maps do not simply get made but are carefully designed to be purposeful to an audience.	All useful maps are designed.	Effective theory-building is a design process that seeks appropriate (for a purpose and audience) rather than true theory.
An effective map/theory is evaluated	P/C	Effective maps regularly undergo various forms of evaluation to assess their effectiveness among their intended audience.	All useful maps are evaluated.	Effective theory-building is a design process that continuously evaluates the appropriateness (for a purpose and audience) of theory.
An effective map/theory is visual	P	The effectiveness of maps as cognitive devices is down to their visual appearance. Visual excellence ensures that complex ideas are communicated with clarity, precision, and efficiency.	All maps are visual.	While traditional theories are over reliant on language, effective theory embraces the effectiveness of the visual as a means of communication of its purpose to its audience.
An effective map/theory limits	C	Effective maps are strategically *scaled* to represent only a select geographic area, a limited set of its spatial features, and in limited detail.	A small-scale map that shows a town as little more than a dot or a large-scale map that shows a single building is of no use to a pedestrian, who must navigate a few blocks. The scales of the maps limit their usefulness to the pedestrian.	Traditional theory is not equally effective across a multitude of domains. Effective theory is limited in its domain so as to be appropriate for a purpose and to its audience.
An effective map/theory prioritizes	C	Effective maps are strategically *generalized* to prioritize certain aspects of the geographic area whereby important things are visible and look important.	A street map of a town that prioritizes features such as culverts, manholes, pipes and cables is of limited use to a pedestrian who must navigate a few blocks. The lack of prioritization of the map limits its usefulness to the pedestrian.	Traditional theory does not always prioritise appropriately. Effective theory highlights those theoretic features that are appropriate for a purpose and its audience.
An effective map/theory simplifies	C	Effective maps are also strategically *generalized* to omit less important aspects, prevent overlapping features, and ensure the features are visually recognizable.	A street map of a town should exclude engineering features and include the positions of pedestrian crossings in order to be useful to a pedestrian.	Traditional theory does not always simplify appropriately. Effective theory simplifies in peripheral areas but retains its detail in areas central to its purpose and its audience.
An effective map/theory is inaccurate	C	Owing to prioritization and simplification, effective maps are inaccurate especially in relation to less prioritised features. Such misrepresentation may be necessary in order for the map to retain legibility.	Gas mains and electric cables often run in close proximity along streets. An engineering map of a town may display both by moving one relative to the other provided resulting inaccuracy does not prevent the map from achieving its purpose.	Traditional theories are neither true nor accurate. Effective theory is also imprecise but is appropriately detailed and precise in those areas central to its purpose and its audience.

[6] P=Presentation Principle. C=Content Principle

Discussion and Concluding Remarks

This paper makes contributions at several levels, which we discuss here. Scholars should benefit from our discussion of the communication issues afflicting theory-building efforts, which we believe to be a more in-depth and pragmatic discourse than offered elsewhere in the academic literature, as well as our response to these issues through introducing the concept of *effective theory*. We posit that *effective theories* stretch beyond the remit of *good theories* to address the content and presentation problems endemic to many theory-building efforts. Scholars are provided with "*a long list of potential criteria for 'good theory'*" (Gregor 2006 p. 25) but there is no general agreement among theory-building authorities concerning the relative importance of each criterion or virtue (Wacker 1998). While each virtue is highly significant for theory-building "*there are always trade-offs among virtues*", which demand value judgments from the scholar (Wacker 1998 p. 367). It is the intention of this paper not to argue against these virtues but to provide scholars with an overarching set of principles to guide them in making the trade-offs.

Our conceptual work stands squarely on the shoulders of maps, which pre-date number systems and written language. From considered reflection on the craft and science of map-making, we derive a model and a set of principles to guide efforts at creating *effective theories*. Whereas the criteria for *good theory* are rather idealistic and non-harmonious, the principles for *effective theory* are realistic and harmonious. All decisions the scholar makes in building *effective theory* are guided by the purpose of the theory and its intended audience. This provides the scholar with a clear anchor point for all decision-making regarding the design of theories. This anchor point is notably missing from the discourse on *good theory*.

In any case it is interesting to do a cross comparison of the virtues of *good theory* and the principles of *effective theory*. First, there is as we might expect some degree of overlap (e.g. between *parsimony* on the one hand and *simplicity* on the other) but also apparent contradictions (e.g. between *generalisation* and *abstraction* on the one hand and *limitation* and *prioritization* on the other). For example, Wacker (1998 p. 365) states that "*[i]f one theory can be applied to one type of environment and another theory can be applied to many environments, then the second theory is a more virtuous theory since it can be more widely applied*". On the other hand we disagree and state that theory should be limited and prioritised. However, once we introduce the anchor point of purposefulness the apparent contradiction dissolves. We posit that generalisation and abstractness are contingent on purposefulness, meaning that their levels are dictated by the purpose of the theory and its audience. In other words the theory should be general and abstract only to the degree that it continues to achieve its purpose. Unfortunately, extant literature omits the anchor point of purposefulness and instead suggests that the function of research is to create theories of high generality. For example, Gregor (2006 p. 7) states that "*abstraction and generalisation … are thought to be at the core of a theory*". We respectfully disagree and suggest that purposefulness should be at the core of a theory. The raison d'être of research is to be useful. If the outcome of a search for purposefulness happens to be theories of high abstraction and high generalisation then great but we believe that purposeful theories are likely to be of a more limited domain – because of necessary trade-offs between generality, simplicity and accuracy. A more limited domain ensures a degree of accuracy and simplicity that may be necessary in order to ensure the appropriateness of the theory for a given purpose and its intended audience.

It may puzzle some readers that we include a principle stating that an *effective theory* is inaccurate. All theories are uncertain and are no more than approximate representations of a reality (Gregor 2002b). No theory can therefore be wholly true or accurate. Creating effective theories through limiting, prioritizing, or simplifying must by the nature of these activities introduce inaccuracies. Indeed we suggest that the accuracy of theories should be downplayed in favour of their appropriateness. While Wacker (2008a p. 8) recognizes that "*[a] 'good' theory may not be a 'true' theory*", we concur but add that they can at least be effective. Truth is unattainable but effectiveness is achievable. So when Wacker (2008a p. 5) states that "*[b]y fulfilling the requirements of good theory, researchers will develop studies that will have a lasting impact on their academic field*" we must disagree. *Good theories* are not necessarily *effective theories*, with the results that "*many potentially good notions fail to get the attention that they deserve as a result of weak or ineffective writing*" (Klimoski 1991). We hope that one benefit of this paper is a realisation on the reader of the limitations of *good theory* and an increased awareness of the need for *effective theory.* Our purpose for establishing the principles presented in this paper is to assist scholars, reviewers, editors, and readers in understanding the requirements for the design of *effective theory*. We advise against mandatory or rote use of the principles. Instead scholars must use their judgment to determine when, where, and how to apply each of the

principles when theory-building. However, we contend that each of the principles should be addressed in some manner for the theory-building to be deemed complete.

Contributions to IS Theory-Building

In this section we return to the issues of identity and legitimacy in the IS field. We remind the reader that in a previous section we related the issues of legitimacy and identity in IS to the relevancy of the theories it produces.

While theory-building "*is an important endeavor, and the IS field's success in this endeavor will certainly help legitimize the IS field*" (Lyytinen et al. 2004 p. 231), theory-building on its own is not sufficient. Ultimately legitimacy of an academic field must come from its stakeholders agreeing that the field provides them with relevant research of real value (King et al. 2006). But extant literature provides limited insight into how we should build theories relevant to our stakeholders. There is confusion over who IS research should appeal to and how it should matter more to them. Most of the IS discourse reduces the question of relevancy, firstly, to the perspective of external stakeholders and, secondly, to content issues. In this way it largely ignores the importance of internal stakeholders and presentation issues. The result is that "*IS research de facto has pursued relevance more in the context of relevance for academic communities*" (Hirschheim et al. 2003 p. 260). For example, Galliers and Land (1987 p. 901) propose that "*if the fruits of our research fail to be applicable in the real world, then our endeavors are relegated to the point of being irrelevant*". But Hirschheim & Klein (2003 p. 259) state that "*stakeholders from within academia are equally or even more important than external stakeholders, because they control the advancement of IS researchers*". While Benbasat & Zmud (1999 p. 5) also focus on practitioners, they at least recognize that "*articles that are not read, regardless of their content, are not relevant*". They therefore relate the issue of relevancy with the need for effective communication. Unfortunately the IS field has reached the stage whereby both internal and external stakeholders "*do not look for enlightenment through IS research*" (p. 253) and there is, therefore, an urgent "*need to strengthen the communicative functions of our research*" (p. 262) (Hirschheim et al. 2003).

So extant literature largely ignores that there is a "*double communication deficit*" between IS and *both* its internal and external stakeholders (Hirschheim et al. 2003 p. 260). Secondly, the extant literature fails to recognise that issues of *both* content and presentation effectiveness of theories must be addressed. But on the other hand, *effective theories* are built to be appropriate in both their content and presentation for either internal or external stakeholders. We therefore posit that effective theory-building is ideally suited to addressing issues of legitimacy in the IS field. Indeed, we suggest that theory-building or indeed good theory-building on its own is insufficient and effective theory-building is the bridge we must cross to legitimacy for our field.

Concluding Remarks for Further Research

Another contribution of this paper is that we move the design and evaluation of theory centre stage. Our call for *effective theory* requires that our community focuses more of its collective attention on the craft and science of theory-building, as well as sharpens its awareness of the factors that impact the effectiveness of theories. Theories are not simply built but must be carefully and methodically designed and subsequently evaluated to ensure fitness for purpose. We therefore must understand the 'how' and 'what' of theory-building. This resonates with Gregor's (2009 p. 1) recent call for theorizing to "*be considered in a holistic manner that links two modes of theorizing: an interior mode with the how of artifact construction studied and an exterior mode with the what of existing artifacts studied*". We propose that theories be viewed as cognitive artefacts and that we need to understand which of their features contribute to making them successes or failures in different environments as well as why and how they work. In other words we need not just to build and evaluate but also to "*theorize and then justify theories about those artefacts*" (March et al. 1995 p. 259).

Extending this line of enquiry, we ask whether theory itself can be an artefact in the sense of design science. Peffers et al. (2007 p. 49) states that the artefact in design science can be "*any designed object with an embedded solution to an understood research problem*". Iivari (2007 p. 50) suggests that "[*o]ne could maintain that [design science] has a lot in common with theory building, which has been of considerable interest in the methodology of science*" but other than noting their similarities they do not pursue the question of their relatedness. While there now appears to be widespread acceptance that we can build theory from within design science, the interesting question of a design science of theory has not been pursued. Although this question is likely to lead to challenging ontological, epistemological, and methodological concerns for some scholars, we nonetheless feel it is a question worth

addressing. "*[D]esign theory can … be produced by researchers who reflect at second-hand on what others have done in constructing artefacts*" (Gregor 2009 p. 6). We feel that theory-building has a lot to learn from considered reflections on exemplars of not just well built theory but also poorly built theory and from communication of the findings to our community. Gregor (2009 p. 7) suggests that "*systemization of knowledge gained through practice is a legitimate academic activity and one that has led to a number of influential design theories*". Therefore, we argue that we need to systematically extract and abstract design principles for theory-building from extant literature. Our field is in urgent need of the knowledge base of theory-building that would result from such an initiative and it is hoped that IS researchers would reflect and adjudicate on the merits of this call to action.

References

Anson, R.W., and Ormeling, F.J. *Basic Cartography for Students and Technicians, Volume 2* Oxford: Butterworth-Heinemann, UK (published on behalf of ICA), 2002.

Bacharach, S.B. "Organizational theories: Some criteria for evaluation," *Academy of Management Review* (14:4) 1989, pp 496–515.

Bakshi, S., and Krishna, S. "Crisis in the Information Systems Discipline: A Reflection," ACIS 2007 Proceedings, Toowoomba, Queensland, Australia, 2007, p. 27.

Barkowsky, T., and Freksa, C. "Cognitive requirements on making and interpreting maps," *Spatial Information Theory A Theoretical Basis for GIS*) 1997, pp 347–361.

Barnes, L.B., Christensen, C.R., and Hansen, A.J. *Teaching and the case method: Text, cases, and readings* Harvard Business Press, 1994.

Bartunek, J.M. "Academic-practitioner collaboration need not require joint or relevant research: Toward a relational scholarship of integration," *Academy of Management Journal* (50:6) 2007, pp 1323-1333.

Benbasat, I., and Zmud, R.W. "Empirical research in information systems: the practice of relevance," *MIS Quarterly* (23:1) 1999, pp 3–16

Benbasat, I., and Zmud, R.W. "The identity crisis within the IS discipline: Defining and communicating the discipline's core properties," *MIS Quarterly* (27:2) 2003, pp 183–194

Berendt, B., Barkowsky, T., Freksa, C., and Kelter, S. "Spatial representation with aspect maps," in: *Spatial Cognition*, 1998, pp. 313–336.

Burton-Jones, A., McLean, E.R., and Monod, E. "In Pursuit of MIS Theories: Process, Variance, and Systems," Working Paper, Department of Computer Information Systems, Georgia State University, 2004.

Campbell, J.P. "The role of theory in industrial and organizational psychology," *Handbook of industrial and organizational psychology* (1) 1990, pp 39–73.

Colquitt, J.A., and Zapata-Phelan, C.P. "Trends in theory building and theory testing: A five-decade study of the Academy of Management Journal," *Academy of Management Journal* (50:6) 2007, p 1281.

Colville, I.D., Waterman, R.H., and Weick, K.E. "Organizing and the search for excellence: making sense of the times in theory and practice," *Organization* (6:1) 1999, p 129.

Cook, T.D., and Campbell, D.T. *Quasi-experimentation: Design and analysis issues for field studies* Houghton Mifflin, Boston, Massachusetts, USA, 1979.

Crapo, A.W., Waisel, L.B., Wallace, W.A., and Willemain, T.R. "Visualization and the process of modeling: a cognitive-theoretic view," in: *Proceedings of the sixth ACM SIGKDD international conference on Knowledge discovery and data mining*, 2000, pp. 218–226

Daft, R.L. "The evolution of organization analysis in ASQ, 1959-1979," *Administrative Science Quarterly* (25:4) 1980, pp 623–636.

Doty, D.H., and Glick, W.H. "Typologies as a unique form of theory building: Toward improved understanding and modeling," *Academy of Management Review* (19:2) 1994, pp 230–251.

Dubin, R. *Theory building* Free Press New York 1978.

Finke, R. *Creative imagery: Discoveries and inventions in visualization* Lawrence Erlbaum Associates, 1990.

Galliers, R.D. "Change as crisis or growth? Toward a trans-disciplinary view of information systems as a field of study: A response to Benbasat and Zmud's call for returning to the IT artifact," *Journal of the Association for Information Systems* (4:6) 2003, pp 337–351

Galliers, R.D., and Land, F.F. "Viewpoint: choosing appropriate information systems research methodologies," *Communications of the ACM* (30:11) 1987, pp 901-902.

Geller, M.J. "Mapping the universe," *Bulletin of the American Academy of Arts and Sciences* (45:2) 1991, pp 41–54.

Gregor, S. "Design theory in information systems," *Australian Journal of Information Systems* (10) 2002a, pp 14–22.

Gregor, S. "A theory of Theories in Information Systems," in: *Information Systems Foundations: building the theoretical base,* S. Gregor and D. Hart (eds.), Australian National University, Canberra, Australia, 2002b, pp. 1–20.

Gregor, S. "The nature of theory in information systems," *MIS Quarterly* (30:3) 2006, pp 611-642.

Gregor, S. "Building theory in the sciences of the artificial," 4th International Conference on Design Science Research in Information Systems and Technology, ACM, Philadelphia, Pennsylvania, US, 2009, pp. 1-10.

Griffin, E.A. *A first look at communication theory* McGraw-Hill New York, 1991.

Harley, J.B. "Deconstructing the map," *Cartographica: The International Journal for Geographic Information and Geovisualization* (26:2) 1989, pp 1–20.

Hempel, C.G. "Fundamentals of taxonomy," *Aspects of scientific explanation*) 1965, pp 137–154.

Hevner, A.R., March, S.T., Park, J., and Ram, S. "Design science in information systems research," *MIS Quarterly* (28:1) 2004, pp 75-105.

Hirschheim, R., and Klein, H.K. "Crisis in the IS Field? A Critical Reflection on the State of the Discipline," *Journal of the Association for Information Systems* (4:5) 2003, pp 237-293.

Hughes, R.I.G. "Models and representation," *Philosophy of Science* (64) 1997, pp 325–336.

Iivari, J. "A Paradigmatic Analysis of Information Systems As a Design Science," *Scandinavian Journal of Information Systems* (19:2) 2007, p 5.

Imhof, E. *Cartographic relief presentation* Walter de Gruyter and Company Publishers, Berlin, 1982.

Jenks, G.F. "Cartographic Education In Today's Geography Departments/Thoughts After Forty Years," *Cartographica: The International Journal for Geographic Information and Geovisualization* (24:2) 1987, pp 112–127.

Keates, J.S. *Cartographic design and production* Halsted Press, 1989.

King, J., and Lyytinen, K. "The Future of the IS Field: Drawing Directions from Multiple Maps," in: *Information Systems: The State of the Field* J. King and K. Lyytinen (eds.), John Wiley & Sons, 2006.

Kitchin, R., Perkins, C., and Dodge, M. "Thinking about maps," in: *In Dodge, M., Kitchin, R., and Perkins, C. (Eds) Rethinking Maps. Routledge, London*, Routledge, 2009.

Klimoski, R. "Theory presentation in human resource management," *Human Resource Management Review* (1:4) 1991, pp 253–271.

Korzybski, A. "Science and Sanity: An Introduction to Non-Aristotelian Systems and General Semantics, (Lakeville: The International Non," *Aristotelian Library Publishing Company* (6) 1948, pp 201–568.

Krygier, J. "How Useful is Tufte for Making Maps?," available at http://makingmaps.net/2007/08/16/how-useful-is-tufte-for-making-maps/, 2007.

Krygier, J. "More Principles of Map Design ", available at http://makingmaps.net/2008/02/05/more-principles-of-map-design/, 2008.

Krygier, J., and Wood, D. *Making maps: a visual guide to map design for GIS* The Guilford Press, 2005.

Krygier, J., and Wood, D. "Ce n'est pas le monde (This is not the world)," *Rethinking Maps*) 2009, p 189.

Kuhn, T.S. *The structure of scientific revolutions* University of Chicago Press, Chicago, IL, 1996.

Larkin, J.H., and Simon, H.A. "Why a diagram is (sometimes) worth ten thousand words," *Cognitive science* (11:1) 1987, pp 65–100.

Li, Z., and Openshaw, S. "A natural principle for the objective generalization of digital maps," *Cartography and Geographic Information Science* (20:1) 1993, pp 19–29.

Lloyd, R. "Cognitive maps: Encoding and decoding information," *Annals of the Association of American Geographers* (79:1) 1989, pp 101–124.

Lynham, S.A. "Theory building in the human resource development profession," *Human Resource Development Quarterly* (11:2) 2000, pp 159–178

Lynham, S.A. "The General Method of Theory-Building Research in Applied Disciplines," *Advances in Developing Human Resources* (4:3) 2002, pp 221-241

Lyytinen, K., and King, J.L. "Nothing at the center?: Academic legitimacy in the information systems field," *Journal of the Association for Information Systems* (5:6) 2004, pp 220-246.

MacEachren, A.M. "Application of environmental learning theory to spatial knowledge acquisition from maps," *Annals of the Association of American Geographers* (82:2) 1992a, pp 245–274.

MacEachren, A.M. "Learning Spatial Information from Maps: Can Orientation-Specificity Be Overcome?," *The Professional Geographer* (44:4) 1992b, pp 431–443.

MacEachren, A.M., and Kraak, M.J. "Exploratory cartographic visualization: advancing the agenda," *Computers & Geosciences* (23:4) 1997, pp 335–343.

Mahoney, J.T., and Sanchez, R. "Building new management theory by integrating processes and products of thought," *Journal of Management Inquiry* (13:1) 2004, pp 34-47.

March, S.T., and Smith, G.F. "Design and natural science research on information technology," *Decision Support Systems* (15:4) 1995, pp 251-266.

Markus, M.L., and Robey, D. "Information technology and organizational change: causal structure in theory and research," *Management Science* (34:5) 1988, pp 583–598.

Massey, A.P., and Wallace, W.A. "Understanding and facilitating group problem structuring and formulation: mental representations, interaction, and representation aids," *Decision Support Systems* (17:4) 1996, pp 253–274.

Merton, R.K. *On theoretical sociology: Five essays, old and new* Free Press New York, 1967.

Metcalfe, M. "Theory: Seeking a plain English explanation," *Journal of Information Technology Theory and Applications* (6:2) 2004, pp 13-21

Mintzberg, H. "Developing theory about the development of theory," in: *KG Smith and M. Hitt, A (eds.), Great Minds in Management: The Process of Theory Development*, 2005, pp. 355–372

Montello, D.R. "Cognitive map-design research in the twentieth century: Theoretical and empirical approaches," *Cartography and Geographic Information Science* (29:3) 2002, pp 283–304.

Nastasia, D.I., and Rakow, L.F. "What Is Theory? Puzzles and Maps as Metaphors in Communication Theory," *tripleC-Cognition, Communication, Co-operation* (8:1) 2009, p 1.

O'Raghallaigh, P., and, D.S., and Murphy, C. "Theory-building using Typologies - A Worked Example of Building a Typology of Knowledge Activities for Innovation," in: *Bridging the Socio-technical Gap in Decision Support Systems - Challenges for the Next Decade, DSS 2010, the 15th IFIP WG8.3 International Conference on Decision Support Systems* Various (ed.), IOS Press, Faculty of Sciences, University of Lisbon, Portugal, 2010, pp. 371-382.

Okada, A., Shum, S.J.B., and Sherborne, T. *Knowledge Cartography: software tools and mapping techniques* Springer-Verlag New York Inc, 2008.

Peffers, K., Tuunanen, T., Rothenberger, M.A., and Chatterjee, S. "A design science research methodology for information systems research," *Journal of Management Information Systems* (24:3) 2007, pp 45-77.

Pidd, M. "Just modeling through: A rough guide to modeling," *Interfaces* (29:2) 1999, pp 118–132.

Pinker, S. *How the mind works* WW Norton & Company, 1999.

Popper, K.R. *The logic of scientific discovery* Hutchinson, 1959.

Robinson, A.H. *The look of maps: an examination of cartographic design* Univ of Wisconsin Pr, 1952.

Rynes, S.L., Bartunek, J.M., and Daft, R.L. "Across the great divide: Knowledge creation and transfer between practitioners and academics," *Academy of Management Journal* (44:2) 2001, pp 340–355.

Schneberger, S., Pollard, C., and Watson, H. "Theories: For Academics and Practitioners," *Information Systems Management* (26:1) 2009, pp 52-60

Shapiro, D.L., Kirkman, B.L., and Courtney, H.G. "Perceived causes and solutions of the translation problem in management research," *Academy of Management Journal* (50:2) 2007, pp 249–266

Silver, M.S., Markus, M.L., and Beath, C.M. "The information technology interaction model: a foundation for the MBA core course," *MIS Quarterly* (19:3) 1995, p 390.

Simon, H.A. *Models of man: Social and rational* John Wiley, 1957.

Simon, H.A. "The Business School a Problem in Organizational Design," *Journal of Management Studies* (4:1) 1967, pp 1–16.

Simon, H.A. "The Sciences of the Artificial," *MIT Press Books* (1) 1996.

Sutton, R.I., and Staw, B.M. "What theory is not," *Administrative Science Quarterly* (40:3) 1995, pp 371-384.

Swoyer, C. "Structural representation and surrogative reasoning," *Synthese* (87:3) 1991, pp 449–508.

Thorngate, W. "Possible limits on a science of social behavior," *Social psychology in transition* (121) 1976, p 139.

Van de Ven, A.H., Angle, H.L., and Poole, M.S. *Research on the Management of Innovation* Harper & Row New York 1989.

Wacker, J.G. "A definition of theory: research guidelines for different theory-building research methods in operations management," *Journal of Operations Management* (16:4) 1998, pp 361–385

Wacker, J.G. "A conceptual understanding of requirements for theory-building research: Guidelines for scientific theory building " *Journal of Supply Chain Management* (44:3) 2008a, pp 5–15.

Wacker, J.G. "Tragic Conceptual Flaws of Theory-Building Empirical Research," *Decision Line*) 2008b, pp 10--12.

Weber, R. "Still desperately seeking the IT artifact," *MIS Quarterly* (27:2) 2003.

Weber, R. "Like Ships Passing in the Night: The Debate on the Core of the Information Systems Discipline," in: *Information Systems: The State of the Field* J. King and K. Lyytinen (eds.), John Wiley 2006.

Weick, K.E. "Amendments to organizational theorizing," *Academy of Management Journal* (17:3) 1974, pp 487–502.

Weick, K.E. "Theory construction as disciplined imagination," *Academy of Management Review* (14:4) 1989, pp 516–531.

Weick, K.E. "Conclusion: Theory construction as disciplined reflexivity: Tradeoffs in the 90s," *Academy of Management Review* (24:4) 1999, pp 797–806.

Weick, K.E. "The experience of theorizing," in: *Great minds in management: The process of theory development,* K.G. Smith and M.A. Hitt (eds.), Oxford University Press, US, 2005, pp. 394-413.

Whetten, D.A. "What constitutes a theoretical contribution?," *Academy of Management Review* (14:4) 1989, pp 490–495.